RESEARCH ARTICLE

Effect of Natural Mordant on Dyeing Process of Some Egyptian Cotton Fabrics using Natural Dye

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ABSTRACT: This paper aims to study eco-textile dyeing of long stable Egyptian cotton fabric of Giza 86 and Giza 90 with natural dye turmeric. Mordanting was done by three different techniques namely Pre-mordanting, simultaneous-mordanting and after-mordanting at the time of dyeing using tannic acid as natural mordant. Fabrics were also dyed using ferrous sulphate as mineral mordant to compare with natural mordant samples. Treated fabric samples were tested for their dyeing performance in terms of (K/S, L, a, b, C, H) and fastness properties (wash, perspiration (acidic and alkaline), and light). The obtained results showed improvement of the cotton samples properties in per-treatment using tannic acid and gave a deeper shade than the other samples. These results were very important in industrial application for the production of Egyptian cotton textile with low cost.

KEYWORDS: Egyptian cotton, natural mordant, natural dye, color components, fastness properties.

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1. INTRODUCTION

The dyeing with natural colorants was one of the oldest techniques practiced by the ancient civilization people [1]. Natural dyes are more eco-friendly can perform better biodegradability and generally have a higher compatibility with the environment. Furthermore, natural dyed textiles also have good UV-protection and antibacterial activity [2]. Natural dyes produce very lustrous and soothing shades as compared to synthetic dyes [3]. Natural dyes contain natural coloring matter which is neither carcinogenic nor hazardous to environment. These colors are non-allergic and non-toxic to human body and perpetuate an ancient tradition. Some dyes even have some therapeutic values for which the raw materials find use in medicine fields [4- 5]. Much natural dye color fades bleed badly without mordanting. Most natural dyes are non-substantive dyes, which mean that they have a little coloring power within themselves and they required the mordents for fixation of dye into the fiber [6]. With the help of mordents, different colors and its tones can be obtained from a single dye source. Turmeric (curcumin) is the most popular natural dye. Turmeric is a rich source of phenolic compounds called curcuminoids [7]. The active coloring ingredient in turmeric rhizome is Curcumin, which is also known as Natural Yellow 3 (C.I. 75300). Turmeric (curcumin) is the brightest yellow natural dye, which belongs to the diaroylmethane group named diferuloylemethane [7]. Turmeric is also well-known for its anti-carcinogenic, anti-microbial, anti-parasitic, anti-mutagenic and anti-inceptive properties, as well as for the formation of sunscreen products [8-9]. Turmeric dye is mostly non-substantive and must be applied on textiles with the help of mordents, usually a metallic salt, having an affinity for the dye and the fiber [10]. Cotton is the most important natural textile fiber, as well as cellulosic textile fiber in the world, used to produce apparel, home furnishings, and industrial products. Worldwide about 40% of the fiber consumed was cotton [11]. Cotton is a natural fiber, however it, does not contain nitrogen within its structure and for the purpose of dyeing with natural dyes needs to be mordanted. Pre- mordanting and post-mordanting with iron and aluminum improves the light fastness and washing fastness of turmeric dye on cotton [12]. Mordants are metal salts which produce an affinity between the fabric and the dye [7]. Alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. are commonly used as mordents [13]. Shuvo et al pointed out an effort to determine the effect of some natural and artificial mordents on various natural dyes for cotton fabric dyeing [14]. Most common mordant for cotton is thus tannin or tannic acid. It occurs in many tannin containing substances, especially in gall nuts which has about 60-70% tannic acid. Treatment with tannic acid helps the cotton fabric to absorb all types of metallic mordents. The metallic mordents form complex with the carboxylic groups of tannic acid. Frequently the purpose of preparing the cotton fibers with tannin is not so much to fix the coloring matter, although that is the final goal, as to fix certain metallic salts such as alum, copper, tin and iron in the form of insoluble tannates. Iron (ferrous sulfate) is called copperas. It will sadden or darken colors, bringing out green shades. Usually cotton and wool is dyed before mordanting with iron when darker shades are required. Simmering dye-bath for ½ hour, too much

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iron will harden wool and make it streak, reported by [15]. The purpose of our research was to dye cotton fabric with turmeric extract, using low concentrations of different mordents and different mordanting application methods, i.e. mordanting prior, during and fiber dyeing, and to evaluate which mordanting technique gives higher dye ability with turmeric. For a successful commercial use of natural dyes for any type of textile, the appropriate and standardized techniques of dyeing need to be adopted [16].

2. MATERIALS AND METHOD

2.1 Materials

2.1.1 Fabrics

The fabric samples used in this investigation were long sable Egyptian cotton plain weaved of Giza 86 and Giza 90 purchased from Misr-El-Mehala Company for Spinning and Textile-Egypt. The specification of both Giza86 and Giza 90 cotton fabrics were given in Table1. Specimens of size of 25 cm x 25 cm were used.

2.1.2 Chemicals

All chemicals used in this study were of analytical grade. Sodium hydroxide, Sodium silicate, Sodium carbonate, hydrogen peroxide, Triton X100 (wetting agent), Magnesium sulphate.

Dye: the natural dye turmeric. Its general formula is given in Figure (1).

2.1.3 Mordants

- Metal mordant: Ferrous sulphate, $Fe(SO_4)_2$.
- Natural mordant: Tannic acid.

2.2 METHODS

2.2.1 Scouring and bleaching treatments

Scouring and bleaching was carried out according to Salah et al [17]**.** Scouring of the fabric samples was performed by the pad-steam technique by padding the fabric with 3% NaOH containing 1.5 to 2% of the wetting agent in a two-bowel padding mangle adjusting the squeeze pressure to enable 100% wet pick-up of the fabric and subsequently steamed in a laboratory steamer at 100°C for 10 min. The scoured fabric was washed with water, neutralized with dilute acetic acid, further washed with water and finally dried in air. The scoured fabrics were immersed in alkaline bleach liquor (180 ml dH_2O), containing Na_2CO_3 (0.2 g/l), NaOH (1.5 g/l), SiO_2 (0.4 g/l), Mg_SO_4 (0.2 g/l), Triton 100 (0.5 g/l) and H_2O_2 (10 ml-1) were added to the bleaching liquor. The samples were removed from the liquor and neutralized with aqueous solution containing 0.1% acetic acid followed by a through hot water (80 to 85°C) to ensure removal of residual chemicals. Samples were dried in an oven at 100°C for 60 min.

2.3 Preparation of Mordant Liquor

2.3.1 Mordanting method

The application methods of mordanting were pre-mordanting (mordanting before dyeing), meta-mordanting (mordanting during dyeing) and post-mordanting (mordanting after dyeing). The concentration of mordents was 0.2 gpl of ferrous sulphate and 20gpl of tannic acid. Pre-and post-mordanting was performed at goods to liquor ratio 1:40 for 10 min at room temperature. The samples were then dried in the oven at 130°C, for 5 min. Meta-mordanting was performed during dyeing.

2.3.2 Dyeing with simultaneous mordanting

The mordant liquor was prepared as the above method and then added to the bath containing the prepared dye solution. The mixture will be boiled at 80^0Cfor 15-20 minutes. The material to liquor ratio 1:60 was maintained.

2.3.3 Dyeing Process

For dyeing, a common procedure is used for every sample. All these dyeing processes were done in a closed bath at 90°C for minutes. Each sample was of 2gm. After dyeing, the dyed fabrics were washed with soap solution of 1g/L and then dried.

All the dyeing process of the three techniques carried out using the dyeing curve.

Table 1: specifications of Giza 86, and Giza 90 cotton fabrics

Cotton	color	Yarn count (Tex)	plain woven cm	Weight g/m²
Giza 86	White	38 x 40	warp 38 yarn, weft 40 yarn	175
Giza 90	Creamy	36× 30	warp 36 yarn, weft 30 yarn	150

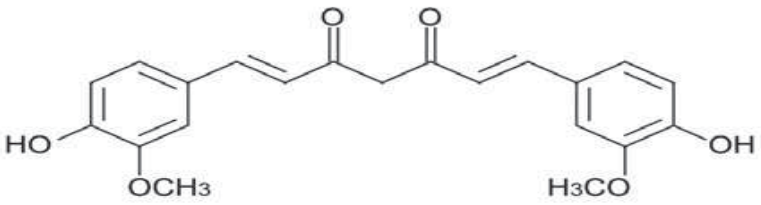

Figure 1 Chemical structure of turmeric (curcumin) (keto form)

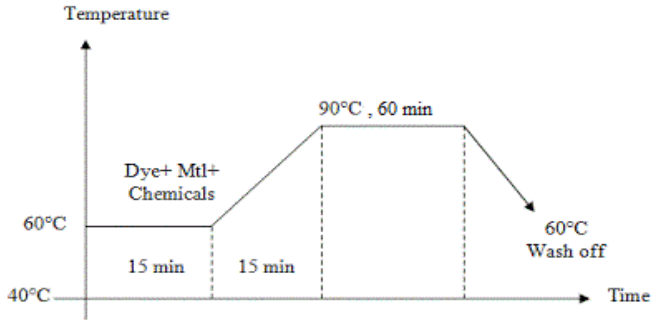

Figure 2: Schematic chart of dyeing processes

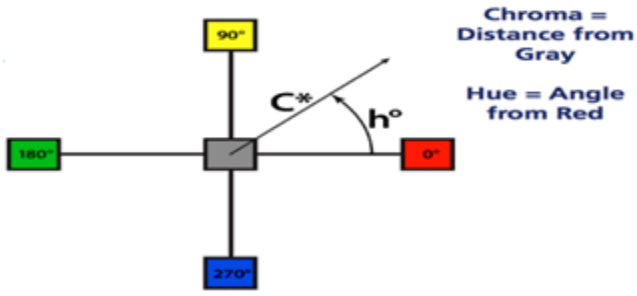

Chart 1: Color components diagram

2.4-Evaluation Tests

2.4.1-Measurement of Color Strength

The color yield of the dyed fabrics was measured using (Perkin-Elmer Company–USA, of model Lambda 35) Spectrophotometer under the illuminant D65 using 10 standard observer. The reflectance values (R) of the dyed fabric at wavelength of maximum absorption (λ max) were converted to the corresponding K/S value using the Kubelka-Munk equation:

$$K/S = (1- R)^2 / 2R$$

Where; K is the absorption coefficient and S is the scattering coefficient.

The measurement was done in accordance to ASTM E313-96 using CIE color system coordinates. The color components were represented in Chart1.

2.4.2-Fastness measurements

Wash fastness testing of the dyed samples was done by the standard method ISO-105-C10: (2015).

Light fastness of the dyed samples was tested on Q-Sun Xenon Test Chamber by the standard method ISO 105 B02: (2014). Perspiration fastness of the dyed samples was measured on perspirometer by the standard method ISO 105 E04: (2013).

3. RESULTS AND DISCUSSIONS

3.1 Effect of mordents on dye uptake

For Giza 90 and from Table (2) and Figure (3), the results showed a high value of K/S in per-treatment with tannic acid and high value in simultaneous treatment with ferrous sulphate. The results may be due to that the dyeing of cotton fabrics with curcumin dye takes place via a weak complex formation between the dye and the natural mordant of mineral mordant producing a charged complex. On soaking the fabric into the solution, a reaction between the hydroxyl groups in the fabric surface and the charged complex carried out [18]. Tannin is not a metal salt; actually it is a water-soluble phenolic compound. When tannic acid was used as mordant, the turmeric and tannin react forming strong complexes. The structure and physical properties of these complexes depend on the nature of the metal ion. For Giza 86, it has been noted that the higher value of K/S with Simultaneous treatment using tannic acid or ferrous sulphate mordents. The difference may be attributed to the physical properties of both cotton samples such as the maturity and finesses expressed as micronair reading, and length of cellulosic chain contains amorphous and crystalline rejoin of cellulose.

3.2 Effect of mordents on color components

Table (3), represented the changes in color components for cotton sample with respect to different natural or metal mordants. The results obtained revealed that there were drastic changes of L*, a*, b*, C, and Hue. The lightness (L*) values indicate that the higher (L*) of the sample, the higher is its luminosity [19]. L* values indicate the difference in luminosity between samples. The data obtained showed that the lightness values reached to 80.39, 80.03, 82.17, and

88.33, 82.68, and 88.69 with pre, on time, and past mrdanting with tannic acid and ferrous sulphate for Giza 86 respectively. On the other hand, the lightness values reached to 78.23, 69.45, 80.61, and 83.83, 79.45, and 85.54 with pre, on time, and past mordanting with tannic acid and ferrous sulphate for Giza 90 respectively. The (a*) values have drastic change with natural or metal mordant for both cotton fabric Giza90 or Giza 86 and with the mordanting treatments. In the presence of ferrous sulphate mordant, the fabric samples were more redness in compared with the fabrics with tannic acid mordant. The (+b*) values indicated that the cotton fabrics tends to the pale yellow color, and the (+b*) values has its maximum in simultaneous mordanting in the presence of tannic for both cotton fabrics, and in pre mordanting in the presence of ferrous sulphate mordant. The hue angle (h) was from 85 degree to 74 for Giza 86 and Giza 90 in simultaneous mordanting in the presence of tannic acid, and from 69 to 67 for Giza 86 and Giza 90 in simultaneous mordanting in the presence of ferrous sulphate. The results indicated that the cotton fabric with tannic acid tends to the yellow color more than that of the samples treated with ferrous sulphate. From Table (3), we find that the saturation of the color values has its maximum in simultaneous mordanting in the presence of tannic acid and in pre mordanting in the presence of ferrous sulphate for both cotton fabrics. For the color components (L, a, b, C, and H), the optimum conditions for both cotton fabrics were as follows: for Giza 86 in the presence of tannic acid, the values were (80.03%, 1.03, 13.9, 14.1%, and 85.5 degree) in simultaneous mordanting. In the presence of ferrous sulphate, the values were (88.33%, 4.09, 7.2, 11.93%, 69.92 degree) in pre mordanting. For Giza 90 in the presence of tannic acid, the values were (69.45%, 3.54, 5.03, 12.15%, 74.82 degree) in simultaneous mordanting. In the presence of ferrous sulphate, the values were (79.45%, 2.87, 10.6, 57.24%, 66.69 degree) in pre mordanting.

Table (2): The effect of two different mordant on K/S for some Egyptian cotton varieties

Varieties	Mordant	Mordant Treatments	K/S
Giza86	(Natural mordant) Tannic acid	Pre-treatment	1.12
		dyeing Simultaneous	1.13
		After-dyeing	1.11
	(Chemical mordant) Ferrous sulphate	Pre-treatment	1.15
		Dyeing Simultaneous	1.20
		After-dyeing	1.10
Giza90	Tannic acid	Pre-treatment	3.14
		Dyeing Simultaneous	2.12
		After-dyeing	2.10
	Ferrous sulphate	Pre-treatment	1.18
		dyeing Simultaneous	1.25
		After-dyeing	1.11

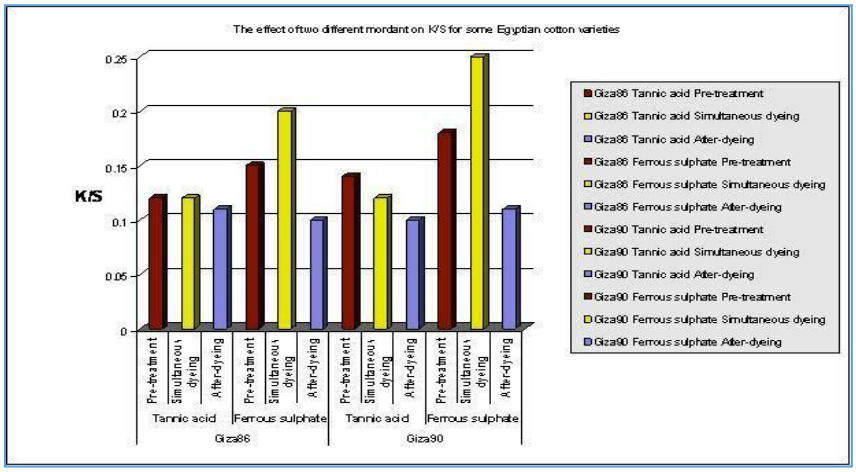

Figure 3: Effect of natural and chemical mordant on K/S of two Egyptian cotton varieties.

Table 3 Effect of natural and chemical mordant on colour components, yellowness and whiteness index of Egyptian cotton varieties

Varieties	Mordant	Dyeing method	Color components				
			L	a	b	Cab	hab
Giza86	Tannic acid	Pre-treatment	80.39	1.82	12.25	12.38	81.55
		Simultaneous dyeing	80.03	1.03	13.9	14.1	85.5
		After-dyeing	82.17	2.31	13.66	13.86	80.41
	Ferrous sulphate	Pre-treatment	88.33	4.09	7.2	11.93	69.92
		Simultaneous dyeing	82.68	4.77	5.91	7.59	51.1
		After-dyeing	88.69	3.16	5.76	6.57	61.24
Giza90	Tannic acid	Pre-treatment	78.23	2.31	11.37	11.6	78.52
		Simultaneous dyeing	69.45	3.54	5.03	12.15	74.82
		After-dyeing	80.61	2.06	9.76	9.97	78.09
	Ferrous sulphate	Pre-treatment	79.45	2.87	10.65	7.24	66.69
		Simultaneous dyeing	83.83	3.54	5.03	6.15	54.82
		After-dyeing	85.54	2.36	11.71	2.92	45.94

Table 4 Effect of natural and chemical mordant on color fastness for the two Egyptian cotton fabrics.

Varieties	Mordents	Mordent techniques	Washing fastness	Light fastness	Perspiration fastness	
					alkaline	acidic
Giza 86	Tannic acid	Pre-treatment	3	5	3	3-4
		Simultaneous dyeing	3	3	3-4	3-4
		After-dyeing	3	4	3	3-4
	Ferrous sulphate	Pre-treatment	3	5	3-4	3-4
		Simultaneous dyeing	3-4	6	3-4	3-4
		After-dyeing	3	5	4	4
Giza 90	Tannic acid	Pre-treatment	3	5	3-4	3-4
		Simultaneous dyeing	3	4	3-4	3-4
		After-dyeing	3	4	4	4
	Ferrous sulphate	Pre-treatment	3-4	4-4	4	3-4
		Simultaneous dyeing	3-4	5	3-4	3-4
		After-dyeing	3-4	5	4	4

4. CONCLUSIONS

Nowadays natural dyes are commonly used for textile industries, due to their harmless effects and harmful consequences of synthetic dyes. The use of natural dyes has increased for dyeing the textile materials after the treatment of fabrics with different mordents. Eco-textile dyeing of long stable Egyptian cotton fabric of Giza 86 and Giza 90 with natural dye turmeric was carried out. Mordanting was done by three different techniques namely Pre-mordanting, simultaneous-mordanting and after-mordanting at the time of dyeing using tannic acid as natural mordant. Fabrics were also dyed using ferrous sulphate as mineral mordant to compare with natural mordent samples. The obtained results showed improvement of the cotton samples properties in per-treatment using tannic acid and gave a deeper shade than the other samples. These results were very important in industrial application for the production of Egyptian cotton textile with low cost.

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